

ANNEXES

ANNEX 1 Event study methodology

The list of completed events using the baseline methodology presented in the text is shown for government debt accumulation episodes in Table A1.1, for private debt accumulation episodes in Table A1.2, and for crisis events Table A1.3. Median durations and amplitudes of these episodes are shown in Table A1.4, and for combined government and private debt accumulation episodes in Table A1.5. The results are robust to using mean or subsamples of countries (Tables A1.6, A1.7).

An alternative dating algorithm is used as robustness test. The alternative definition of debt accumulation episodes is in line with the literature on credit booms. To control for financial development, the literature on private credit booms identifies credit booms as sizable deviations of credit-to-GDP ratios from their trend (Mendoza and Terrones 2008). Applying this approach here, a debt accumulation is identified as the period between the trough and the peak in the government or private debt-to-GDP ratio provided at some point during the period the deviation of the debt-to-GDP ratio exceeds one standard deviation from its Hodrick-Prescott-filtered trend.

While this approach identifies a larger number of episodes, three quarters of these episodes have overlapping peaks or troughs (two thirds have overlapping peaks) and most results are robust to the use of this alternative definition (Table A1.8). The median episode extends for 7 (government) to 8 (private) years; the median episode features a debt buildup of 11 (private) to 30 (government) percent; more than half of government debt episodes and about one-half of all debt episodes are associated with crises.

ANNEX TABLE 1.1 Completed episodes of rapid accumulation of government debt

Albania	2007-2015				
Algeria	1970-1978	1982-1988 ^{1 2}	1992-1995 ²		
Angola	1997-1999				
Argentina	1968-1975 ²	1980-1989 ^{1 2 3}	1992-2002 ^{1 2 3}		
Aruba	2000-2002				
Azerbaijan	1994-1999 ¹				
Bangladesh	1973-1977 ²	1980-1987 ¹	1989-1994	1997-2002	
Belarus	2005-2011 ²	2013-2016 ²			
Benin	1972-1983	1992-1994 ²	2006-2011		
Bolivia	1970-1985 ^{1 2 3}	2001-2004			
Bosnia and Herzegovina	2007-2014				
Brazil	1967-1987 ^{2 3}	1989-1992 ^{1 2}	1995-2002 ²		
Bulgaria	1981-1993 ³				
Burkina Faso	1970-1987	1989-1994 ^{1 2}			
Burundi	1971-1999 ¹	2001-2004			
Cambodia	1995-2003				
Cameroon	1970-1979	1984-1995 ^{1 2 3}			
Central African Republic	1970-1974 ¹	1979-1984	1990-1994 ^{1 2}	1999-2005	2009-2014
Chad	1972-1979	1986-1994 ^{1 2}	1998-2000		
Chile	1962-1970	1972-1975 ^{1 2}	1981-1986 ^{1 2 3}		
China	1997-2003 ¹	2006-2009			
Colombia	1960-1972	1978-1986 ^{1 2}	1995-2002 ¹		
Congo, Dem. Rep.	1970-1976 ^{2 3}	1979-1983 ^{1 2}	1993-1998 ^{1 2}		
Congo, Rep.	1973-1985 ³	1992-1994 ^{1 2}	2011-2016		
Costa Rica	1958-1973	1975-1978	1988-2002 ^{1 2}		
Côte d'Ivoire	1970-1994 ^{1 2 3}				
Croatia	1998-2005 ¹	2007-2014			
Dominican Republic	1997-2003 ^{1 2 3}	2007-2013			
Ecuador	1997-1999 ^{1 2 3}				
Egypt, Arab Rep.	1970-1982 ^{1 2 3}	1989-1992 ²	2000-2005		
El Salvador	1977-1985 ²				
Eritrea	1995-2003				
Ethiopia	1974-1994 ²				
Georgia	2007-2010				
Ghana	1982-1987 ^{1 2}	1990-1994 ²	1998-2000 ²		
Guatemala	1954-1972	1975-1985 ²	2008-2013		

ANNEX TABLE 1.1 Completed episodes of rapid accumulation of government debt (*continued*)

Guinea	1992-1999 ¹	2003-2005 ²		
Haiti	1973-1983	1985-1992 ^{1 2}	2011-2016	
Honduras	1950-1986 ³			
Hungary	1989-1993 ¹	2001-2011 ¹		
India	1974-1992 ¹	1996-2003		
Indonesia	1980-1987	1997-2000 ^{1 2 3}		
Iran, Islamic Rep.	1974-1981	1985-1988 ²	2011-2016 ²	
Jordan	1969-1990 ^{1 2 3}			
Kazakhstan	1996-1999 ²	2007-2015 ^{1 2}		
Kenya	1963-1982	1984-1987 ¹	1989-1993 ^{1 2}	
Kuwait	1987-1991			
Kyrgyz Republic	1994-2000 ^{1 2}	2013-2015		
Lao PDR	1976-1982 ²	1985-1988 ²		1996-1998 ²
Lebanon	1972-1983 ²	1987-1990 ¹	1993-2006	
Libya	1977-1990			
Madagascar	1976-1988 ^{1 2 3}			
Malawi	1975-1987 ³	1991-1994 ²	1997-2002	
Malaysia	1955-1972	1974-1977	1980-1987	2007-2015
Mali	1973-1985 ¹	1990-1994 ²		
Mauritania	1970-1987 ¹	1992-2000 ²		
Mexico	1971-1977 ²	1980-1987 ^{1 2 3}	1993-1995 ^{1 2}	2007-2016
Moldova	2008-2015 ¹			
Mongolia	1992-1999 ²			
Morocco	1974-1985 ^{1 2 3}			
Mozambique	2007-2016 ²			
Nepal	1970-1994 ^{1 2}	1997-1999		
Niger	1970-1974	1977-1985 ^{1 3}	1989-1994 ²	1996-2000
Nigeria	1975-1991 ^{1 2 3}			
North Macedonia	2008-2016			
Oman	1990-1994			
Pakistan	1962-1972 ²	1981-2001	2007-2013	
Panama	1975-1983 ³	1985-1990 ¹		
Papua New Guinea	1970-1976	1978-2001 ²	2011-2016	
Paraguay	1981-1987 ^{2 3}	1996-2002 ²		
Peru	2001-2003			

ANNEX TABLE 1.1 Completed episodes of rapid accumulation of government debt (*continued*)

Philippines	1963-1972	1974-1987 ^{1 2 3}	1998-2003 ²		
Poland	1990-1994 ¹	2000-2013			
Romania	1995-2000 ^{1 2}	2007-2014			
Russian Federation	1996-1999 ^{1 2 3}				
Rwanda	1975-1995 ²	1998-2002			
Saudi Arabia	1989-1999				
Senegal	1972-1985 ³	1992-1994 ²			
Sierra Leone	1970-1994 ^{1 2 3}				
South Africa	1964-1972	1974-1978	1990-1995		
Sri Lanka	1970-1982 ²	1984-1989 ¹	1997-2002		
Sudan	2007-2012 ²				
Syrian Arab Republic	1975-1989 ²				
Tanzania	1970-1980	1982-1993 ^{1 2 3}			
Thailand	1963-1972	1975-1986 ¹	1996-2000 ^{1 2}		
Togo	1972-1985 ³	1990-1994 ^{1 2}	1997-2000	2004-2007	2010-2016
Tunisia	1975-1978	1980-1997 ¹			
Turkey	1958-1970	1974-1985 ^{1 2 3}	1990-1994 ²	1998-2001 ^{1 2}	
Ukraine	1995-1999 ^{1 2 3}	2007-2016 ^{1 2 3}			
United Arab Emirates	1973-1979	1981-1988	1990-1993	2001-2009	
Uruguay	1970-1976 ²	1979-1984 ^{1 2 3}	1996-2003 ^{1 2 3}		
Uzbekistan	1997-2001 ²				
Venezuela, RB	1964-1972	1975-1994 ^{1 2 3}	2000-2003 ²	2008-2013 ²	
Vietnam	2005-2016				
West Bank and Gaza	2000-2005	2010-2015			
Yemen, Rep.	1994-1996 ^{1 2}				
Zambia	1970-1982 ^{2 3}	1987-1991 ²	1997-2000		
Zimbabwe	1975-1987 ²	1989-1998 ^{1 2}	2001-2009 ²	2012-2016	

Note: Superscripts 1, 2, and 3 mean that rapid accumulation episodes are associated with banking, currency, and debt crises, respectively. Underlined years indicate episodes that are still underway.

ANNEX TABLE 1.2 Completed episodes of rapid accumulation of private debt

Algeria	1997-2002	2004-2009		
Angola	2000-2009			
Argentina	1965-1974 ²	1976-1982 ^{1 2 3}	1985-1989 ^{1 2}	1991-2002 ^{1 2 3}
Aruba	1986-1990	1993-1996	1998-2003	
Azerbaijan	1996-2009	2011-2015 ²		
Bangladesh	1974-1990 ^{1 2}			
Belarus	1994-1998 ^{1 2}	2001-2010 ²		
Benin	1966-1975	1981-1983	2002-2016	
Bolivia	1986-1999 ¹			
Bosnia and Herzegovina	2001-2008			
Brazil	2004-2015 ²			
Bulgaria	1994-2009 ^{1 2}			
Burkina Faso	1960-1978	1984-1990 ¹	1995-1997	2002-2009
Burundi	1969-1981	1985-1994 ¹	1997-2002	2008-2011
Cameroon	1997-2016			
Central African Republic	1994-2004 ^{1 2}	2006-2013		
Chile	1980-1984 ^{1 2 3}	1988-2002	2006-2015	
China	1980-1993	1995-2003 ¹		
Colombia	1990-1998 ¹	2005-2015		
Congo, Rep.	1996-1999	2006-2016		
Costa Rica	1991-2008 ^{1 2}			
Croatia	2000-2012			
Dominican Republic	1985-1987 ²	1991-2002 ^{1 2 3}		
Ecuador	1974-1978	1980-1984 ^{1 2 3}	1989-2000 ^{1 2 3}	
Egypt, Arab Rep.	1973-1986 ^{1 2 3}	1992-2001	2014-2016 ²	
El Salvador	1990-2000	2002-2007		
Ethiopia	1962-1978	1991-1999 ²	2004-2006	
Ghana	1967-1971	1981-1989 ^{1 2}	1991-2008 ²	2011-2015 ²
Guatemala	1973-1984 ²	1991-2006	2011-2015	
Guinea	1991-1995 ¹	1999-2006 ²	2009-2015	
Haiti	1992-2002 ^{1 2}	2007-2014		
Honduras	1950-1978	1981-1987 ³	1995-2007	
Hungary	1969-1987	1995-2009 ¹		

ANNEX TABLE 1.2 Completed episodes of rapid accumulation of private debt (*continued*)

India	1967-1989	1994-2013			
Indonesia	1980-1990	1993-1997 ^{1 2 3}	2009-2015		
Iran, Islamic	1955-1970	1974-1980	1984-1986 ²	1996-2016 ²	
Jordan	1972-1989 ^{1 2 3}	1992-2001	2003-2006		
Kazakhstan	1997-2007 ^{1 2}				
Kenya	1966-1980	1987-2004 ^{1 2}	2006-2015		
Kosovo	2001-2011	2013-2018			
Kuwait	1971-1990 ¹	1993-1998	2006-2009	2012-2016	
Kyrgyz	1997-2008 ²	2011-2018			
Lao PDR	1989-1998 ²	2006-2010			
Lebanon	1970-1982 ²	1993-2000	2005-2017		
Liberia	1988-1996 ¹	2000-2016			
Libya	1980-1988	1991-1995	2007-2015		
Madagascar	1975-1980 ³	1983-1986 ^{1 2}	1989-1991	2002-2015 ²	
Malawi	1965-1971	1973-1979	1988-1992 ²	1997-2012 ²	1997-2012 ²
Malaysia	1955-1986	1988-1991	1993-1997 ^{1 2}	2008-2016	2008-2016
Mali	1966-1976	1994-1999 ²	2001-2004		
Mauritania	2006-2009				
Mexico	1983-1986	1988-1995 ^{1 2}	2010-2016		
Moldova	1994-2007 ^{2 3}				
Mongolia	1997-2007 ^{1 2}	2010-2013			
Morocco	1990-2000	2003-2012			
Mozambique	1996-2000	2004-2015 ²			
Myanmar	1965-1972	1974-1978 ²	1989-1992 ²	1994-2001 ²	
Nepal	1963-1981	1983-2009 ^{1 2}			
Nicaragua	1975-1982 ^{2 3}	1996-2007 ¹			
Niger	1971-1975	1977-1981 ^{1 3}			
Nigeria	1970-1980	1990-1992 ¹	1996-2001 ²	2006-2009 ¹	
North	2001-2015				
Oman	1972-1978	1981-1988	1990-1998	2005-2009	2011-2017
Pakistan	1957-1972 ²	1975-1979	1984-1986	1991-2000	2002-2008
Panama	1990-2001				
Papua New	1978-1987	1996-1998	2004-2013		
Paraguay	1961-1971	1987-1997 ^{1 2}	2006-2015		
Peru	1969-1973	1978-1983 ^{1 2 3}	1989-1999	2006-2015	

ANNEX TABLE 1.2 Completed episodes of rapid accumulation of private debt (*continued*)

Philippines	1971-1983 ^{1 2 3}	1986-1997 ^{1 2}			
Poland	1995-2002	2004-2016			
Romania	2000-2011				
Russian	1996-2015 ^{1 2 3}				
Rwanda	1968-1978	1983-1988	1991-1994 ²	1996-2015	
Saudi Arabia	1973-1988	1990-1998	2000-2009	2012-2016	
Senegal	1967-1979 ³				
Serbia	2002-2010				
Sierra Leone	1971-1978 ³	1999-2009			
South Africa	1967-1973	1980-1985 ^{2 3}	1993-2008		
Sri Lanka	1973-1979 ²	1991-1995	2009-2017		
Sudan	1974-1980 ^{2 3}	1999-2012 ²			
Syrian Arab	1980-1984	1988-1995 ²	2002-2010		
Tajikistan	2004-2008	2010-2015 ²			
Tanzania	2000-2008	2013-2015			
Thailand	1950-1997 ^{1 2}	2007-2015			
Togo	1965-1980 ³	1985-1987	1990-1993 ^{1 2}	2002-2016	
Tunisia	1980-1986	1988-2002 ¹	2006-2017		
Turkey	1989-1997 ²				
Uganda	1979-1981 ^{2 3}	1987-2015 ^{1 2}			
Ukraine	1996-2009 ^{1 2 3}				
United Arab	1973-1978	1980-1988	1990-1998	2000-2009	2013-2016
Uruguay	1974-1982 ^{1 2 3}	1994-2002 ^{1 2 3}			
Venezuela, RB	1963-1978	2003-2013 ²			
Vietnam	1992-2010 ¹				
West Bank and	1998-2006	2008-2016			
Yemen, Rep.	1996-2007 ¹				
Zambia	1965-1974	1978-1982 ^{2 3}	1992-1996 ^{1 2}	2002-2008 ²	2010-2015 ²
Zimbabwe	1982-1989 ²	1994-1997 ^{1 2}	1999-2002 ²		

Note: Superscripts 1, 2, and 3 mean that rapid accumulation episodes are associated with banking, currency, and debt crises, respectively. Underlined years indicate episodes that are still underway.

ANNEX TABLE 1.3 List of financial crises

Country	Systemic Banking Crisis (starting date)	Currency Crisis (year)	Sovereign Debt Crisis (year)
Albania	1994	1997	1990
Algeria	1990	1988, 1994	
Angola		1991, 1996, 2015	1988
Argentina	1980, 1989, 1995, 2001	1975, 1981, 1987, 2002, 2013	1982, 2001, 2014
Armenia	1994		
Austria	2008		
Azerbaijan	1995	2015	
Bangladesh	1987	1976	
Belarus	1995	1997, 2009, 2015	
Belgium	2008		
Belize			2007, 2012, 2017
Benin	1988	1994	
Bolivia	1986, 1994	1973, 1981	1980
Bosnia and Herzegovina	1992		
Botswana		1984	
Brazil	1990, 1994	1976, 1982, 1987, 1992, 1999, 2015	1983
Bulgaria	1996	1996	1990
Burkina Faso	1990	1994	
Burundi	1994		
Cambodia		1971, 1992	
Cameroon	1987, 1995	1994	1989
Cabo Verde	1993		
Central African Republic	1976, 1995	1994	
Chad	1983, 1992	1994	
Chile	1976, 1981	1972, 1982	1983
China	1998		
Colombia	1982, 1998	1985	
Comoros		1994	
Congo, Dem. Rep.	1983, 1991, 1994	1976, 1983, 1989, 1994, 1999, 2009, 2016	1976
Congo, Rep.	1992	1994	1986
Costa Rica	1987, 1994	1981, 1991	1981
Côte d'Ivoire	1988	1994	1984, 2001, 2010
Croatia	1998		
Czech Republic	1996		
Cyprus	2011		2013
Denmark	2008		
Djibouti	1991		
Dominica			2002
Dominican Republic	2003	1985, 1990, 2003	1982, 2003
Ecuador	1982, 1998	1982, 1999	1982, 1999, 2008
Egypt, Arab Rep.	1980	1979, 1990, 2016	1984

ANNEX TABLE 1.3 List of financial crises (*continued*)

Country	Systemic Banking Crisis (starting date)	Currency Crisis (year)	Sovereign Debt Crisis (year)
El Salvador	1989	1986	
Equatorial Guinea	1983	1980, 1994	
Eritrea	1993		
Estonia	1992	1992	
Eswatini	1995	1985, 2015	
Ethiopia		1993	
Fiji		1998	
Finland	1991	1993	
France	2008		
Gabon		1994	1986, 2002
Gambia, The		1985, 2003	1986
Georgia	1991	1992, 1999	
Germany	2008		
Ghana	1982	1978, 1983, 1993, 2000, 2009, 2014	
Greece	2008	1983	2012
Grenada			2004
Guatemala		1986	
Guinea	1985, 1993	1982, 2005	1985
Guinea-Bissau	1995, 2014	1980, 1994	
Guyana	1993	1987	1982
Haiti	1994	1992, 2003	
Honduras		1990	1981
Hungary	1991, 2008		
Iceland	2008	1975, 1981, 1989, 2008	
India	1993		
Indonesia	1997	1979, 1998	1999
Iran, Islamic Rep.		1985, 1993, 2000, 2013	1992
Ireland	2008		
Israel	1983	1975, 1980, 1985	
Italy	2008	1981	
Jamaica	1996	1978, 1983, 1991	1978, 2010
Japan	1997		
Jordan	1989	1989	1989
Kazakhstan	2008	1999, 2015	
Kenya	1985, 1992	1993	
Korea, Rep.	1997	1998	
Kuwait	1982		
Kyrgyz Republic	1995	1997	
Lao PDR		1972, 1978, 1986, 1997	
Latvia	1995, 2008	1992	
Lebanon	1990	1984, 1990	
Lesotho		1985, 2015	
Liberia	1991		1980

ANNEX TABLE 1.3 List of financial crises (*continued*)

Country	Systemic Banking Crisis (starting date)	Currency Crisis (year)	Sovereign Debt Crisis (year)
Libya		2002	
Lithuania	1995	1992	
Luxembourg	2008		
Madagascar	1988	1984, 1994, 2004	1981
Malawi		1994, 2012	1982
Malaysia	1997	1998	
Maldives		1975	
Mali	1987	1994	
Mauritania	1984	1993	
Mexico	1981, 1994	1977, 1982, 1995	1982
Moldova	2014	1999	2002
Mongolia	2008	1990, 1997	
Morocco	1980	1981	1983
Mozambique	1987	1987, 2015	1984
Myanmar		1975, 1990, 1996, 2001, 2007, 2012	
Namibia		1984, 2015	
Nepal	1988	1984, 1992	
Netherlands	2008		
New Caledonia		1981	
New Zealand		1984	
Nicaragua	1990, 2000	1979, 1985, 1990	1980
Niger	1983	1994	1983
Nigeria	1991, 2009	1983, 1989, 1997, 2016	1983
North Macedonia	1993		
Norway	1991		
Pakistan		1972	
Panama	1988		1983
Papua New Guinea		1995	
Paraguay	1995	1984, 1989, 2002	1982
Peru	1983	1976, 1981, 1988	1978
Philippines	1983, 1997	1983, 1998	1983
Poland	1992		1981
Portugal	2008	1983	
Romania	1998	1996	1982
Russian Federation	1998, 2008	1998, 2014	1998
Rwanda		1991	
São Tomé and Príncipe	1992	1987, 1992, 1997	
Senegal	1988	1994	1981
Serbia		2000	
Seychelles		2008	2008
Sierra Leone	1990	1983, 1989, 1998	1977
Slovak Republic	1998		
Slovenia	1992, 2008		
South Africa		1984, 2015	1985

ANNEX TABLE 1.3 List of financial crises (*continued*)

Country	Systemic Banking Crisis (starting date)	Currency Crisis (year)	Sovereign Debt Crisis (year)
South Sudan		2015	
Spain	1977, 2008	1983	
Sri Lanka	1989	1978	
Sudan		1981, 1988, 1993, 2012	1979
Suriname		1990, 1995, 2001, 2016	
Sweden	1991, 2008	1993	
Syrian Arab Republic		1988	
Switzerland	2008		
Tajikistan		1999, 2015	
Tanzania	1987	1985, 1990	1984
Thailand	1983, 1997	1998	
Togo	1993	1994	1979
Trinidad and Tobago		1986	1989
Tunisia	1991		
Turkey	1982, 2000	1978, 1984, 1991, 1996, 2001	1978
Turkmenistan		2008	
Uganda	1994	1980, 1988	1981
Ukraine	1998, 2008, 2014	1998, 2009, 2014	1998, 2015
United Kingdom	2007		
United States	1988, 2007		
Uruguay	1981, 2002	1972, 1983, 1990, 2002	1983, 2002
Uzbekistan		2000	
Venezuela, RB	1994	1984, 1989, 1994, 2002, 2010	1982, 2017
Vietnam	1997	1972, 1981, 1987	1985
Yemen, Rep.	1996	1985, 1995	
Yugoslavia, former			1983
Zambia	1995	1983, 1989, 1996, 2009, 2015	1983
Zimbabwe	1995	1983, 1991, 1998, 2003	

Note: Years of crises are taken from Laeven and Valencia (2018).

ANNEX TABLE 1.4 Duration and amplitude of rapid debt accumulation episodes

A. Duration

Number of episodes, by duration (years)						
Years:	Associated with crises			No crises		
	2-4	5-10	11-	2-4	5-10	11-
Government debt	41	59	37	27	74	18
Private debt	28	39	39	38	83	38
Total debt	32	40	35	29	78	24

B. Amplitude

Number of episodes, by amplitude (percentage points of GDP)								
Percentage points of GDP:	Associated with crises				No crises			
	-20	20-40	40-60	60-	-20	20-40	40-60	60-
Government debt	24	41	24	48	53	40	16	10
Private debt	66	17	13	10	98	48	11	2
Total debt	9	32	26	40	33	57	20	21

Note: Total debt refers to a sum of government debt and private debt. A period of debt accumulation is identified with the algorithm in Harding and Pagan (2002). When a change in debt-to-GDP ratios over an accumulation period is above the maximum of 10-year moving standard deviation of the ratios during the period, it is considered as a rapid debt accumulation.

ANNEX TABLE 1.5 Comparison of combined episodes with single episodes

	Rapid accumulation with crises			Rapid accumulation without crises		
	Government debt	Private debt	Both (combined)	Government debt	Private debt	Both (combined)
Duration (years)	7	8	3	7	8	4
Amplitude (percentage points of GDP)	42.6	13.1	35.3	21.6	14.8	26.0
Growth (percent)	2.2	3.7	2.7	4.1	4.6	4.2
Per capita growth (percent)	0.1	1.9	0.9	2.0	2.5	2.0
Investment growth (percent)	1.9	5.7	2.2	6.3	7.2	6.1
Private consumption growth (percent)	2.5	4.0	2.9	4.1	4.8	4.2
Reserves (percent of GDP)	7.2	7.2	6.6	12.9	13.2	12.9
Short-term external debt (percent of GDP)	4.4	4.8	4.3	3.9	3.7	3.8

Note: A combined episode covers years with concurrent government and private debt accumulation episodes. Single episodes cover years with a solely-government debt accumulation episode or a solely-private debt accumulation episode. Amplitude for "Both (combined)" is measured as an average of amplitudes of government debt and private debt during a combined government and private debt accumulation episode. Bold numbers indicate statistically significant difference from combined episodes.

ANNEX TABLE 1.6 Robustness exercises: Government debt

Cumulative change in eight years from the beginning of rapid government debt accumulation								
	Baseline		Baseline (Mean)		Advanced economies		All countries	
	Crises	No crises	Crises	No crises	Crises	No crises	Crises	No crises
Output	127	141	127	140	112	120	125	129
Per capita output	107	120	108	116	106	116	107	117
Investment	130	167	154	183	102	111	118	129
Private consumption	130	139	131	138	111	119	125	126
Consumer price	198	141	626	171	116	123	186	133
REER	88	101	100	103	95	100	92	100
Current account balance	-28	-25	-30	-28	-7	-7	-26	-19
Fiscal balance	-37	-27	-39	-28	-34	-22	-35	-23
Reserves	60	105	89	128	60	91	60	102
Total external debt	402	365	460	458	-	-	402	365
Short-term external debt	48	33	65	42	-	-	48	33

Note: A table shows cumulative levels or shares of GDP in eight years since the beginning of rapid accumulation episodes (year "t") of government debt (Panel A) and private debt (Panel B). Output, per capita output, investment, private consumption, consumer price, REER, and debt-to-GDP ratio are presented as an index equal to 100 in year "t" while current account balance, fiscal balance, reserves, total external debt, and short-term external debt are in percent of GDP. "Baseline" shows medians; "Mean" shows average results; "Rolling window" uses 10-year moving standard deviations (over t-9 and t) to identify episodes; "Lower threshold" uses half of country-specific standard deviations; "Advanced economies" uses data for advanced economies. The numbers in bold show that differences between crises and non-crises are statistically significant at least at the 10 percent level.

ANNEX TABLE 1.7 Robustness exercises: Private debt

Cumulative change in eight years from the beginning of rapid private debt accumulation								
	Baseline		Baseline (Mean)		Advanced economies		All countries	
	Crises	No crises	Crises	No crises	Crises	No crises	Crises	No crises
Output	133	143	135	147	123	128	130	139
Per capita output	112	119	115	119	121	119	115	119
Investment	146	171	174	245	139	132	142	156
Private consumption	135	146	140	161	124	128	134	139
Consumer price	211	145	440	163	138	132	195	141
REER	99	109	105	112	106	104	102	108
Current account balance	-28	-32	-27	-8	-4	-5	-21	-23
Fiscal balance	-28	-18	-33	-10	-26	-18	-27	-18
Reserves	65	112	82	173	55	71	61	105
Total external debt	509	367	569	458	-	-	509	367
Short-term external debt	50	38	70	54	-	-	50	38

Note: A table shows cumulative levels or shares of GDP in eight years since the beginning of rapid accumulation episodes (year "t") of government debt (Panel A) and private debt (Panel B). Output, per capita output, investment, private consumption, consumer price, REER, and debt-to-GDP ratio are presented as an index equal to 100 in year "t" while current account balance, fiscal balance, reserves, total external debt, and short-term external debt are in percent of GDP. "Baseline" shows medians; "Mean" shows average results; "Rolling window" uses 10-year moving standard deviations (over t-9 and t) to identify episodes; "Lower threshold" uses half of country-specific standard deviations; "Advanced economies" uses data for advanced economies. The numbers in bold show that differences between crises and non-crises are statistically significant at least at the 10 percent level.

ANNEX TABLE 1.8 Robustness to alternative definition of episodes

	Government debt episodes	Private debt episodes
Number of episodes (count)		
Baseline definition	256	265
Alternative definition	325	362
Share of episodes in baseline and alternative definition		
With same start or end year	71.1	75.5
With same end year	64.5	63.0
Median duration of episode (years)		
Baseline definition	7	8
Alternative definition	7	8
Median amplitude of episode (percentage points of GDP)		
Baseline definition	30.0	14.5
Alternative definition	29.5	10.6

Source: World Bank.

Note: In the baseline definition, an episode is defined as the increase in debt-to-GDP ratio from peak to trough, if the peak-to-trough increase exceeds one country-specific, ten year-rolling standard deviation. In the alternative definition, an episode is defined as the increase in debt-to-GDP ratio from peak to trough if during this period, the debt-to-GDP ratio exceeds its Hodrick-Prescott-filtered trend by one standard deviation at some point during the period from trough to peak debt-to-GDP ratio.

ANNEX 2 Regression methodology

The most common estimation methods used in the empirical literature on predicting crises are logit and probit models. The baseline specification used in this study is a panel logit model with random effects, but for robustness purposes, a random effects probit model and a fixed effects logit model are also used. The Hausman test suggests that the random effects model is appropriate for debt and banking crises but not for currency crises. However, even for currency crises, the coefficient estimates and their statistical significance remain similar in fixed effects and random effects models.

To exploit the time and cross-sectional dimensions, a panel dataset of 139 EMDEs with annual data over the period 1970–2018 is constructed. The basic structure of the model takes the form:

$$Y_{it} = \beta'X_{it-1} + \mu_i + \varepsilon_{it} \quad (1)$$

where Y_{it} is a crisis indicator (either sovereign debt, banking, or currency crisis) for country i in year t , and takes the value of 1 if it is in a crisis, and 0 otherwise; X_{it-1} is the vector of determinants of a crisis; β is the vector of coefficient estimates common across all countries; μ_i captures the unobserved country heterogeneity; and ε_{it} is the stochastic error term.

The probability of a crisis is given by:

$$\Pr(Y_{it} = 1 \mid X_{it-1}, \beta, \mu_i) = \Psi(\mu_i + \beta'X_{it-1}) \quad (2)$$

where assumptions about the distribution of the error terms, that is, the form of ε_{it} renders the estimation of the logit (logistic distribution) or probit (normal distribution) discrete choice panel data model. The parameters can be estimated by maximizing the panel-level likelihood function.

Selection of explanatory variables. The variables are chosen from a close examination of the empirical findings from the early warning crisis literature (see Kaminsky, Lizondo, and Reinhart 1998; Frankel and Saravelos 2012; and Chamon and Crowe 2012 for an extensive review). We include a large number of variables (and various data transformations, such as levels, growth rate, percentage point change, deviation from trend) that can be characterized into several groups:

- Debt profile: public debt, private debt, short-term debt, variable interest rate debt, concessional debt, multilateral debt, commercial debt, IMF credit, debt service

- Capital account: international reserves, currency mismatch, portfolio flows, FDI
- Current account: current account balance, exchange rate overvaluation, exchange rate regime, terms of trade
- Foreign: U.S. interest rate, advanced economies' GDP growth
- Domestic macro: GDP growth, inflation, unemployment, fiscal balance
- Financial sector: credit to private sector, money supply, interest rate
- Banking sector: liquidity, leverage, banking concentration, non-performing loans
- Structural: trade openness, export diversification, capital account openness
- Institutional: governance, conflict, political stability

Some variables had low cross-country coverage and/or limited time series availability (especially banking sector variables and institutional quality indicators), and thus had to be dropped. To attenuate potential endogeneity bias caused by contemporaneous interaction between economic fundamentals and crises, lagged values of the explanatory variables are used, except for U.S. interest rate. The variables used in the baseline model (panel logit random effects model) are listed in Table A2.1 and the estimation results are summarized in Table A2.2. Robustness checks using alternative model specifications are provided in Tables A2.3 and A2.4.

Probability of crises. The probability of crises occurring are evaluated at specific points of interest for illustration (while keeping all other variables at their average values), which include crisis episodes such as Mexico's 1982 twin crises. The findings are summarized in Table A2.5.

Twin crises. The probability of the occurrence of twin crises (any two of sovereign debt, banking, and currency crises) is lower than single crisis events.¹ However, the explanatory variables in the baseline model have better predictive ability in predicting a twin crisis one year ahead.² An adverse GDP

¹ A twin crisis is defined as the occurrence of any two of sovereign debt, banking, or currency crises within two immediate years.

² A triple crisis model (all three types of crisis happening within two immediate years) could not be reliably estimated as there are only 7 such episodes with available data for the explanatory variables.

growth shock, a larger share of short-term debt, higher debt service burden, lower reserve cover, and larger changes in government and private debt significantly increase the probability of a twin crisis, although the interaction term of government and private debt is insignificant. The estimation results are shown in Table A2.6.

Robustness. Several additional correlates were added to the baseline empirical specification to test the robustness of the results. The baseline results are robust to these alternative specifications.³

First, the quality of institutions may affect the incidence of crises. However, data for meaningful cross-country and over-time comparison, such as the Worldwide Governance Indicators (WDI, Kaufmann, Kraay and Mastruzzi 2010), is only available starting in the early 1990s.⁴ As a result, most sovereign debt and banking crises as well as many currency crises, which mainly occurred during the first two waves of debt accumulation, will be omitted from the estimation sample. Indeed, the use of WDI data reduces the number of observations by almost a half. Furthermore, most measures of institutional quality are insignificant, while the results on other variables are broadly of the same magnitude, signs and significance as in the baseline specification. Several statistically significant results are counterintuitive and may reflect other omitted factors.

Second, to account for possible nonlinearity of the impact of debt increases on the probability of crises and its dependence on the level of debt, baseline regressions were augmented with squared changes in debt and interactions between a change in debt and the initial level of debt. In most specifications, these new variables are not statistically significant, while other coefficients remain consistent with the findings of the baseline model.

Third, the foreign exchange regime or a shift in foreign currency regime influence the probability of financial distress but in different ways for different types of crises. An EMDE with a fixed exchange rate is more likely to suffer a sovereign debt crisis, while a shift to a flexible exchange rate increases the likelihood of a banking crisis. A currency crisis is more likely if a shift to a flexible exchange rate regime occurred the year before the crisis. Other regression coefficients remain consistent with the baseline specification regardless of the exchange rate regime.

³ Detailed results are available upon request.

⁴ WDI data is available from 1996 to 2017, but with gaps in 1996-2001.

ANNEX TABLE 2.1 Definition of variables and data sources

Variables	Definition	Source ^a
Crisis	Sovereign debt, banking, or currency crisis	Laeven and Valencia (2018)
Change in U.S. real interest rate	Percentage point change in U.S. real lending interest rate (deflated by GDP deflator)	WDI
GDP growth	Annual percentage growth rate of GDP at market prices based on constant local currency	WDI
Short-term debt	Share of short-term debt (with a maturity of 1 year or less) in external debt	IDS
Debt service	Ratio of debt service on external debt to exports	IDS
Reserve cover	International reserves in months of imports	IDS
Change in government debt	Percentage point change in public debt to GDP ratio	GDD
Change in private debt	Percentage point change in private debt to GDP ratio	GDD
Concessional debt	Share of concessional debt in external debt	IDS
Funding ratio	Ratio of credit provided to private sector to total deposits	GFDD
Currency overvaluation	Percentage deviation of real effective exchange rate from HP-filtered trend	Darvas (2018), World Bank
Currency mismatch	Ratio of foreign liabilities to foreign assets	Lane and Milesi-Ferretti (2018)
FDI	Net inflows of foreign direct investment as a share of GNI	IDS

^a GFDD – Global Financial Development Database; GDD – Global Debt Database, IDS – International Debt Statistics; WDI – World Development Indicators

ANNEX TABLE 2.2 Random effects logit model

Dependent variable: crisis indicator (1 crisis, 0 no crisis)

Explanatory variables	Debt crisis	Banking crisis	Currency crisis
Change in U.S. real interest rate	-0.067 (0.132)	0.015 (0.106)	0.253** (0.100)
GDP growth	-0.095*** (0.025)	-0.020 (0.025)	-0.006 (0.020)
Short-term debt	0.026* (0.015)	0.012 (0.012)	0.006 (0.011)
Debt service	0.028*** (0.009)	0.029*** (0.007)	0.010 (0.008)
Reserves cover	-0.573*** (0.116)	-0.163*** (0.063)	-0.115* (0.062)
Change in government debt	0.014* (0.008)		0.016** (0.007)
Change in private debt		0.055** (0.023)	0.052** (0.026)
Change in government debt x Change in private debt			0.003*** (0.001)
Concessional debt	-0.033*** (0.009)		
Funding ratio		0.002* (0.001)	
Currency overvaluation			0.165*** (0.015)
Currency mismatch			0.014 (0.033)
FDI			-0.101** (0.046)
Constant	-2.678*** (0.616)	-4.161*** (0.371)	-3.617*** (0.395)
No. of observations	3,089	2,797	2,395
No. of countries	106	106	99

Notes: ***, **, * denote statistical significance at the 1 percent, 5 percent, 10 percent level respectively. Standard errors are in parentheses.

ANNEX TABLE 2.3 Random effects probit model

Dependent variable: crisis indicator (1 crisis, 0 no crisis)

Explanatory variables	Debt crisis	Banking crisis	Currency crisis
Change in U.S. real interest rate	-0.027 (0.057)	0.007 (0.046)	0.118** (0.048)
GDP growth	-0.044*** (0.012)	-0.011 (0.011)	-0.006 (0.010)
Short-term debt	0.010 (0.006)	0.005 (0.005)	0.002 (0.005)
Debt service	0.012*** (0.004)	0.013*** (0.003)	0.004 (0.004)
Reserves cover	-0.215*** (0.045)	-0.063*** (0.025)	-0.060** (0.028)
Change in government debt	0.007* (0.004)		0.008* (0.004)
Change in private debt		0.021** (0.010)	0.024* (0.013)
Change in government debt x Change in private debt			0.001*** (0.000)
Concessional debt	-0.014*** (0.004)		
Funding ratio		0.001* (0.001)	
Currency overvaluation			0.079*** (0.007)
Currency mismatch			0.004 (0.016)
FDI			-0.047** (0.020)
Constant	-1.537*** (0.264)	-2.186*** (0.157)	-1.861*** (0.182)
No. of observations	3,089	2,797	2,395
No. of countries	106	106	99

Notes: ***, **, * denote statistical significance at the 1 percent, 5 percent, 10 percent level respectively. Standard errors are in parentheses.

ANNEX TABLE 2.4 Fixed effects logit model

Dependent variable: crisis indicator (1 crisis, 0 no crisis)

Explanatory variables	Debt crisis	Banking crisis	Currency crisis
Change in U.S. real interest rate	-0.121 (0.130)	-0.021 (0.106)	0.257** (0.104)
GDP growth	-0.095*** (0.034)	-0.013 (0.026)	-0.008 (0.022)
Short-term debt	0.056*** (0.020)	0.012 (0.017)	-0.015 (0.016)
Debt service	0.032** (0.015)	0.026*** (0.010)	0.001 (0.011)
Reserves cover	-0.586*** (0.154)	-0.256*** (0.082)	-0.219*** (0.085)
Change in government debt	0.018* (0.010)		0.013** (0.007)
Change in private debt		0.055** (0.027)	0.067** (0.029)
Change in government debt x Change in private debt			0.003*** (0.001)
Concessional debt	-0.059** (0.023)		
Funding ratio		-0.001 (0.003)	
Currency overvaluation			0.131*** (0.016)
Currency mismatch			0.037 (0.049)
FDI			-0.087 (0.059)
No. of observations	1,186	1,705	1,688
No. of countries	35	55	63

Notes: ***, **, * denote statistical significance at the 1 percent, 5 percent, 10 percent level respectively. Standard errors are in parentheses.

ANNEX TABLE 2.5 Probability of crises

Dependent variable: crisis indicator (1 crisis, 0 no crisis)

Explanatory variable	Points of interest	Probability of debt crisis	Probability of banking crisis	Probability of currency crisis	Reference
Change in U.S. real interest rate	2 percentage points vs. unchanged			6.0 percent vs. 4.1 percent	Cumulative increase in U.S. Fed Funds rate from end-2015 to mid-2018 vs. no change in interest rate
GDP growth	-1 percent vs. 4 percent	1.9 percent vs. 1.2 percent			Average EMDE growth during crisis vs. non-crisis episodes
Short-term debt	30 percent vs. 10 percent	2.0 percent vs. 1.2 percent			Mexico's 1982 episode vs. EMDE non-crisis episodes
Debt service	50 percent vs. 15 percent	2.8 percent vs. 1.1 percent	5.5 percent vs. 2.1 percent		Mexico's 1982 episode vs. EMDE non-crisis episodes
Reserves cover	1 month vs. 4 months	3.1 percent vs. 0.6 percent	3.3 percent vs. 2.0 percent	5.0 percent vs. 3.8 percent	Mexico's 1982 episode vs. EMDE non-crisis episodes
Change in government debt	30 percentage points of GDP vs. unchanged	2.0 percent vs. 1.4 percent		6.6 percent vs. 3.9 percent	Median government debt accumulation episode vs. no accumulation
Change in private debt	15 percentage points of GDP vs. unchanged		4.8 percent vs. 2.2 percent	7.5 percent vs. 3.9 percent	Median private debt accumulation episode vs. no accumulation
Concessional debt	50 percent vs. 25 percent	0.8 percent vs. 1.6 percent			Average EMDE crisis vs. non-crisis episodes
Funding ratio	200 percent vs. 90 percent		3.0 percent vs. 2.3 percent		Ukraine's 2008-09 share vs. EMDE non-crisis episodes
Currency overvaluation	15 percent vs. 0 percent			19.5 percent vs. 2.2 percent	Thailand's real appreciation 1994-97

Note: The table shows the predicted probability of crises in the following year evaluated at various points of interest for each explanatory variable (with the other variables held at their average values). These probabilities are included for variables that are statistically significant at the 10 percent level or below in the baseline regressions (see Table A2.2 in Annex 2).

ANNEX TABLE 2.6 Logit and probit models for twin crisis

Dependent variable: crisis indicator (1 crisis, 0 no crisis)

Explanatory variables	Random effects logit	Random effects probit	Fixed effects logit
Change in U.S. real interest rate	0.158 (0.177)	0.068 (0.073)	0.096 (0.184)
GDP growth	-0.075** (0.030)	-0.035** (0.014)	-0.146*** (0.049)
Short-term debt	0.056*** (0.015)	0.022*** (0.007)	0.073*** (0.026)
Debt service	0.038*** (0.012)	0.015*** (0.005)	0.026 (0.017)
Reserves cover	-0.277** (0.120)	-0.107** (0.046)	-0.391** (0.188)
Change in government debt	0.016* (0.009)	0.007 (0.005)	0.018** (0.010)
Change in private debt	0.088*** (0.031)	0.040*** (0.015)	0.161*** (0.060)
Change in government debt x Change in private debt	-0.001 (0.001)	-0.000 (0.001)	-0.004 (0.005)
Constant	-5.639*** (0.584)	-2.716*** (0.228)	
No. of observations	2,908	2,908	696
No. of countries	107	107	21

Notes: ***, **, * denote statistical significance at the 1 percent, 5 percent, 10 percent level respectively. Standard errors are in parentheses.

Annex 3 Case studies

An in-depth literature review covered 43 crisis case studies for 30 EMDEs with financial crises and rapid debt accumulation episodes since 1970. While non-exhaustive, the case studies were chosen to: (i) be representative of debt accumulation episodes over the past fifty years; (ii) include the large EMDEs in major regional debt crises episodes; (iii) represent crises in low-income countries; and (iv) a sufficiently comprehensive literature to base an assessment on. The main sources for in-depth literature reviews are summarized in Table A3.1.

The search covered all publicly available country reports and flagship publications of international financial institutions (Asian Development Bank, African Development Bank, European Bank for Reconstruction and Development, Inter-American Development Bank, International Monetary Fund, World Bank) and academic publications published during 1970–2018. Publications were found on the institutions’ websites and, especially before 1997, in the EconLit database.

Some caution is required when interpreting results. First, not all topics received equal attention. For example, literature on the role of financial supervision during crisis episodes of the 1970s and 80s is limited (for Chile, Larrain 1998; for Uruguay, Leone and Pérez-Campanero 1991; for Philippines, Nascimento 1990; World Bank 1996). However, the decade following the global financial crisis has seen an explosion of financial supervision work and the role of macroprudential policy. This reflects in part the nature of these crises. Second, much of the literature during the 1980s focused on the economies of Latin America that held most of the U.S. banks’ liabilities (Fischer 1989). Sub-Saharan African countries, due to their small liability positions despite the economic impacts on the individual economies being as severe, received much less focus.

ANNEX TABLE 3.1 Information sources

Episode	Main sources
Argentina	Hornbeck 2013; IMF 1989, 2001a, 2016b; Kaufman 1989; Kawai, Newfarmer and Schmukler 2005
Bangladesh	IMF 1974
Brazil	Boughton 2001; IMF 1981a, 2003a
Bolivia	Boughton 2001; IMF 1978a; Kaufmann, Mastruzzi, and Zavaleta 2003; Sachs 1988b; Morales and Sachs 1999;
Cameroon	Daumont, Le Gall, and Leroux 2004; IMF 1998a, 2004b
Chile	Boughton 2001; IMF 1978b, 1982, 1985
Colombia	World Bank 1996
Indonesia	Boughton 2012; IMF 2001b; 2003a
Korea	Boughton 2012; IMF 2001b; 2003a
Malaysia	Boughton 2012; Radelet et al. 1998
Mexico	Boughton 2001, 2012
Nepal	IMF 1984a
Niger	IMF 1998a; 1998b; World Bank 1994
Nigeria	Daumont, Le Gall, and Leroux 2004; IMF 1999b, 2012
Paraguay	IMF 1984b
Peru	Boughton 2001; Sachs 1985
Philippines	IMF 1997; 1999c; Kawai, Newfarmer and Schmukler 2005
Thailand	Boughton 2012; IMF 2001b; Radelet et al. 1998
Uruguay	IMF 1978c, 1981b, 1995, 2001c, 2003b
Venezuela	Boughton 2001, 2012; IMF 1978d
Zimbabwe	Boughton 2012; IMF 1999d, 2001d

Note: Unless otherwise specified, IMF references refer to Article IV staff reports.

ANNEX TABLE 4.1 Income classification of low-income countries

Low-income countries	Income classification	
	Fiscal year 1990	Fiscal year 2020
Afghanistan	L	L
Bangladesh	L	LM
Benin	L	L
Bhutan	L	LM
Burkina Faso	L	L
Burundi	L	L
Cambodia	L	LM
Central African Republic	L	L
Chad	L	L
China	L	UM
Comoros	L	LM
Congo, Dem. Rep.	L	L
Equatorial Guinea	L	UM
Ethiopia	L	L
Gambia, The	L	L
Ghana	L	LM
Guinea	L	L
Guinea-Bissau	L	L
Guyana	L	UM
Haiti	L	L
India	L	LM
Indonesia	L	LM
Kenya	L	LM
Lao PDR	L	LM
Lesotho	L	LM
Liberia	L	L
Madagascar	L	L
Malawi	L	L
Maldives	L	UM
Mali	L	L
Mauritania	L	LM
Mozambique	L	L
Myanmar	L	LM
Nepal	L	L
Niger	L	L
Nigeria	L	LM
Pakistan	L	LM
Rwanda	L	L
São Tomé and Príncipe	L	LM
Sierra Leone	L	L
Somalia	L	L
Sri Lanka	L	UM
Sudan	L	LM
Tanzania	L	L
Togo	L	L
Uganda	L	L
Vietnam	L	LM
Zambia	L	LM

Source: World Bank.

Note: List includes all World Bank Group member countries that were classified as low-income countries in Fiscal Year 1990. L stands for low-income country, LM for lower middle-income country, UM for upper middle-income country.

ANNEX TABLE 4.2 Income classification of countries that have received HIPC or MDRI debt relief

HIPC recipients	Income classification	
	Fiscal year 1996	Fiscal year 2020
Afghanistan	L	L
Benin	L	L
Bolivia	LM	LM
Burkina Faso	L	L
Burundi	L	L
Cameroon	L	LM
Central African Republic	L	L
Chad	L	L
Comoros	L	L
Congo, Rep.	L	LM
Congo, Dem. Rep.	L	L
Côte d'Ivoire	L	LM
Ethiopia	L	L
Gambia, The	L	L
Ghana	L	LM
Guinea	L	L
Guinea-Bissau	L	L
Guyana	L	UM
Haiti	L	L
Honduras	L	LM
Liberia	L	L
Madagascar	L	L
Malawi	L	L
Mali	L	L
Mauritania	L	LM
Mozambique	L	L
Nicaragua	L	LM
Niger	L	L
Rwanda	L	L
São Tomé and Príncipe	L	LM
Senegal	L	L
Sierra Leone	L	L
Tanzania	L	L
Togo	L	L
Uganda	L	L
Zambia	L	LM

Source: World Bank.

Note: HIPC stands for Highly Indebted Poor Countries; MDRI stands for Multilateral Debt Relief Initiative. HIPC initiative was launched in 1996; MDRI initiative in 2005. List includes all HIPC and MDRI debt relief recipients. L stands for low-income country, LM for lower middle-income country, UM for upper middle-income country.

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